

Prestige Asymmetry in American Physics: Aspirations, Applications, and the Purloined Letter Effect

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Argument

Why do similar scientific enterprises garner unequal public approbation? High energy physics attracted considerable attention in the late-twentieth-century United States, whereas condensed matter physics – which occupied the greater proportion of US physicists – remained little known to the public, despite its relevance to ubiquitous consumer technologies. This paper supplements existing accounts of this much remarked-upon prestige asymmetry by showing that popular emphasis on the mundane technological offshoots of condensed matter physics and its focus on human-scale phenomena have rendered it more recondite than its better-known sibling field. News reports about high energy physics emphasize intellectual achievement; reporting on condensed matter physics focuses on technology. And whereas frontier-oriented rhetoric of high energy physics communicates ideals of human potential, discoveries that smack of the mundane highlight human limitations and fail to resonate with the widespread aspirational vision of science – a consequence I call “the purloined letter effect.”

Introduction

In his influential article “More Is Different,” condensed matter physicist Philip W. Anderson wrote, “It is only slightly overstating the case to say that physics is the study of symmetry” (Anderson 1972, 394). Much of physics consists in identifying equivalences between different ways of looking at the world. Asking why Maxwell’s equations are the same for a stationary observer and an observer undergoing uniform rectilinear motion (Lorentz invariance) led Albert Einstein to special relativity (Janssen 2002; Martínez 2004). No less important are genuine asymmetries – or broken symmetries. Why, for instance, does the universe appear to be composed primarily of matter without including an equal measure of anti-matter, a problem known as baryon asymmetry? Why, even though the equations of statistical mechanics are time symmetric, do we experience time only in one direction? Symmetry is a font of deep and fruitful physical questions.

This provides a metaphorical preface to a question about broken symmetry in *history* of physics: why is it conceivable that Peter Higgs might be the answer to a question in a pub trivia quiz, whereas Anderson, quoted above, probably would not be, despite the fact that the two made scientific contributions of a similar variety and order? To put the question more generally, why, through the last decades of the twentieth century, did the comparatively smaller proportion of physics research dedicated to high energy physics garner the lion’s share of both public and scholarly attention, while the field that occupied the most physicists – condensed matter physics, which investigates the physical properties of solids, liquids, molecules, and other materials – remained little known outside specialist circles? This is what I call a *prestige asymmetry*, in which otherwise similar activities garner unequal attention and approbation.¹

Prestige asymmetries suffuse the history of science and technology. They are critical features of both internal professional dynamics and the relationship between science and its publics. Engineers have often labored in the shadow of physical scientists (Kline 1995). Developmental biology, having been sidelined by the mid-twentieth century synthesis of evolutionary biology and molecular genetics, has struggled since to reestablish its prominence (Laubichler and Maienschein 2007). Planetary science, relegated to an astronomical backwater when the study of distant galaxies and nebulae moved to the vanguard, remained so until it became urgently pertinent in the run-up to the Apollo missions (Sevigny 2016). Specific fields gain professional acclaim and public visibility for reasons that cannot be exhausted by appeal to their intrinsic interest or importance. This paper teases out some of those reasons through the case of US physics, and in particular the prestige asymmetry between high energy physics and condensed matter physics that persisted

¹ Historical developments are, of course, far too complex to admit anything so precise as the equivalences that physical symmetries establish. The symmetry metaphor here suggests only a conspicuous difference that demands explanation.

through the late twentieth century and into the twenty-first. Despite its idiosyncrasies, this case suggests larger patterns and raises questions that can help understand prestige asymmetry as a general phenomenon.

Before delving into the causes of this particular prestige asymmetry, it is essential to establish the supposed similarity between high energy and condensed matter physics that makes the asymmetry between them worthy of historical attention. The first basis for comparison is the prominence of these fields within the physics community. Since the mid-1970s, the Division of Condensed Matter Physics and the Division of Particles and Fields have been the two largest topical divisions of the American Physical Society (APS), the flagship professional organization for US physics, with the former hovering between 1.5 and 2 times the size of the latter.² Both take as their central intellectual mission the application a foundational physical theory – quantum mechanics – to matter and energy. High energy physics claims the realm of elementary particles and condensed matter physics focuses on complex matter, and a significant crosspollination has persisted between them (James and Joas 2015; Schweber 2015). The distinction between these two types of research has been institutionalized within the APS. Since the 1950s, the divisions devoted to condensed matter physics, chemical physics, plasma physics, and other investigations of complex matter have held their primary congress during a March meeting of the society, whereas high energy, nuclear, and astrophysicists have met at a separate meeting, usually held in April. These two major annual meetings have since become the central axis along which the society is divided. Finally, US high energy physics and US condensed matter physics have garnered roughly similar degrees of international acclaim, as measured by accolades such as the Nobel Prize, which physicists routinely consider to be the ultimate mark of superlative accomplishment. From 1960, by which time these two fields were both reasonably distinct professional entities, through the end of the century, 20 US high energy physicists (shares of 13 prizes) and 21 US condensed matter physicists (shares of 12 prizes) have been honored by the Royal Swedish Academy of Sciences.³

Despite representing one of the major undertakings of US physics in what is perhaps its most fruitful era, however, condensed matter physics has remained comparatively obscure beyond the physics community. Historical treatments of the subject habitually comment on this fact (Eckert and Schubert 1990, xi; Hoddeson et al. 1992, v; Hoddeson and Daitch 2002, 4–7; Martin and Janssen 2015, 635).

² Data collected from APS.org, as well as the archival records of the American Physical Society held at the American Institute of Physics, Niels Bohr Library and Archives, College Park, MD.

³ Data from Nobelprize.org, including prizes awarded from 1960 and 2000, inclusive. I exclude from both categories awards given for primarily nuclear or astrophysics work. The Nobel Prize is a problematic proxy for scientific merit; work conducted by individuals who were never recognized is often just as or more influential than that of the winners. Given the weight placed on the award within the physics community, however, it is a useful proxy for international professional esteem.

Equally telling are condensed matter physicists' own expressions of concern, which tend to surface in the United States alongside periodic unease about the reliability of federal, taxpayer-supported funding. A 2010 report of the National Research Council lamented that "the general public is largely unaware that CMMP (Condensed Matter and Materials Physics) is the science behind many of the technological marvels that they take for granted" (Committee on CMMP 2010, 146). Journalists and science communicators also acknowledge the deficit. The 1997 edition of *A Field Guide for Science Writers*, describing the challenges of covering physics, noted:

According to Robert L. Park, a physicist who is director of public information for the American Physical Society, the scarcity of stories about physics in newspapers and magazines has contributed to a lack of public understanding about physicists and the research they conduct. Each year in March, for example, the society holds its biggest meeting, a gathering of condensed-matter physicists. "But of the 6,000 papers that are presented," Park says, "only three are suitable for coverage. Condensed-matter physics is never covered in the press. Reporters have never heard of these things." (McDonald 1997, 188–189)

Physicist and science writer Chad Orzel, in his *Forbes* column, also observes the scarcity of press coverage of the APS March meeting (Orzel 2016). Despite widespread acknowledgment from historians, physicists, journalists, and science communicators of the deficit condensed matter physics suffers in the public eye, however, the causes are little examined.

The asymmetry is especially conspicuous considering that hard-headed knowhow has historically held greater currency than high-minded theory in American culture. Reverence for the abstract is supposed to be anathema to the American psyche (see Schweber 1986). Condensed matter physics would therefore seem primed to build a stronger profile with the American public, given its close connections to technology. Science – physics in particular – was considered effete and remote from the concerns of average US citizens through the end of World War II. Daniel J. Kevles, describing the place of science in the post-Civil War United States, suggests: "To applaud science was to set oneself apart socially in a country so exuberant over mere gadgets and machinery" (Kevles 1978, 17). As late as 1944, the president of the APS could grumble, "It is a rare occurrence that a census taker has ever heard of a physicist, and the task of explaining is such that one is often tempted to register as a chemist" (Hull 1944, 66).

Physics would become deeply connected with daily life after World War II, above and beyond the attention nuclear weapons drew to it, with the proliferation of new industrial and consumer technologies exploiting the better physical understanding of metals, semiconductors, and amorphous solids that condensed matter physicists (or solid state physicists, as they were more often called until the 1970s)

pursued.⁴ Basic research rhetoric also became potent in postwar America, beginning with Vannevar Bush's dissemination of the term in *Science – The Endless Frontier* in 1945. Such rhetoric, however, almost always assumed the so-called linear model of innovation, in which basic research is desirable primarily as a precursor of technological, medical, or economic benefits (Godin 2006). Nevertheless, public awareness of physics has rested disproportionately on its more rarefied corners, its most extreme scales, and those physicists who shun practical applications.

The relative public obscurity of condensed matter physics becomes even more surprising when we consider that some of the most visible discussions of science and science funding reverberate around abstract research strictly to the extent that it can generate technological outcomes. Basic research was a recurring theme of the State of the Union addresses during Barack Obama's eight years as president, but each time it was shackled to practical concerns. "Innovation ... demands basic research," he declared in 2012, "Today, the discoveries taking place in our federally financed labs and universities could lead to new treatments that kill cancer cells, but leave healthy ones untouched, new lightweight vests for cops and soldiers that can stop any bullet" (Obama 2012). Similar sentiments appear in each of his addresses between 2009 and 2015. George W. Bush advocated "basic research programs in the physical sciences," which he suggested would "support the work of America's most creative minds as they explore promising areas such as nanotechnology, supercomputing, and alternative energy sources" (Bush 2007). State of the Union addresses stretching back to Dwight D. Eisenhower's commitment to "foster the march of science in helping expand our economy and increasing productivity" cast science as the eager man Friday to technology and economy (Eisenhower 1956).

The consistency with which one of the most listened-to speeches of the year has reinforced the linear model makes it even more remarkable that the basic physical investigations most likely to bear technological fruit have commanded so little attention. This paper reviews existing accounts of the prestige asymmetry between condensed matter physics and high energy physics, establishes their incompleteness, and proposes two further explanations. The first addresses the very centrality of technological applications to public dissemination of condensed matter research. Through an analysis of newspaper and magazine reporting on Nobel Prize announcements, I document a persistent tendency to exalt the intellectual accomplishments of high energy physics on one hand, and, on the other, to direct attention to common consumer technologies and away from intellectual achievement when discussing condensed matter physics.

⁴ Until the 1970s, the field was known as solid state physics—the Division of Solid State Physics, founded in 1947, became the Division of Condensed Matter Physics in 1978. For clarity, I refer to "condensed matter physics" throughout, except when referring to institutions and entities that took the name solid state. For more on the relationship between these names, see Martin 2015b.

Technology, which we might otherwise expect to increase awareness of condensed matter physics, has instead tended to become the overriding story, muting the character and importance of the scientific investigations behind it.

Second, the consequences of this tendency can be compounded if and when the values expressed in science popularization cut against the values upheld more commonly in public discourse about science. Understanding prestige asymmetry requires discerning how the values communicated in the discourse of scientific discovery relate to the values and expectations of the surrounding society. Many in the United States see science as a source of faith in both individual potential and collective possibility, and look to it as a way to overcome human limitations. John H. Evans has documented “faith in science producing meaning” (Evans 2014, 823) and traced an upward trajectory of such commitments in Western, Anglophone societies. Science functions for many as “a source of societal hope – a way to save our society from its troubles, in the same way that societies have looked to other saviors, like religion” (ibid., 814).⁵ Some rhetoric of scientific discovery, however, undercuts the narrative of science as a testament to human potential. When discoveries are presented as evidence that we have missed something obvious, it highlights our failings and limitations alongside our accomplishments. We can only recognize such achievements by also acknowledging our collective failure to discover earlier what was in front of our eyes all along. In these instances, scientific discoveries fail to promote the values that evidence suggests best resonate with consumers of scientific media. I call this the purloined letter effect, after Edgar Allan Poe’s 1844 short story in which a stolen letter hidden in plain sight is uncovered in a way that exposes the police, who had failed to find it, as mulish and unimaginative.

Existing Discussions of Prestige Asymmetry in Physics and Their Limitations

Although prestige asymmetry in physics has yet to receive systematic study, piecemeal explanations appear in assorted scholarly and popular media. Four such candidate explanations for the asymmetry between high energy physics and condensed matter physics bear considering: the emotional power of cosmology; the complexity of condensed matter physics; lack of popularization efforts on the part of condensed matter physicists; and the contingent historical circumstances from which these fields emerged. These explanations often seize on relevant features of the sciences in question, but they prove inadequate, individually or together, to account for the phenomenon.

⁵ The question of whether individuals or groups adopt science as a secular religion is distinct from the question of whether science itself, as an epistemic practice, is a secular religion. The latter possibility is forcibly rejected by Michael Ruse 2003.

The Emotional Power of Cosmology

The phrase “emotional power of cosmology” comes from Sharon Traweek’s classic ethnography of the Stanford Linear Accelerator, *Beamtimes and Lifetimes* (1988, 2). Traweek asks why high energy physics maintained such a powerful hold on the American imagination throughout the Cold War. One reason she proposes is that the role of physicists as custodians of fundamental knowledge reflects an awesome responsibility previously vested in members of holy orders. The study of the basic components of the universe, as carried out by high energy physicists, and its direct conceptual connections to cosmological studies of the universe’s origins and fate, speak to something deep and powerful in the human psyche.

The success of popular media promising to shepherd lay audiences to the meaning hidden in the regions of physics most remote from human experience also testifies to cosmology’s psychological potency. Examples include, most recently, *The Big Picture* by cosmologist Sean Carroll (2016). In a striking testament to the power of the view that science can serve up secular meaning, Carroll suggested that his book should, like the Gideon Bible, be installed in hotel nightstands worldwide (Brooks 2016). The 2014 television series *Cosmos: A Spacetime Odyssey*, which premiered to 8.5 million viewers in the United States and 40 million globally, presented an insistent argument that science was equipped to serve as the principal source of facts about the universe *and* of a meaningful sense of our place in it (statistics from Fahy 2015, 198).

Other scholars join Traweek in documenting the psychological draw of certain types of scientific investigation. Marshall Missner’s examination of Albert Einstein’s rise to fame in the United States identifies the dream-like quality often associated with the counterintuitive, four-dimensional geometry of relativity as a factor in its rapid saturation of the public consciousness (Missner 1985). Nasser Zakariya’s discussion of George Gamow and Harlow Shapley shows how they linked astronomical questions to a deep fascination with origins, especially the origins of life, to present science as a synthesized and meaning-laden enterprise (Zakariya 2012).

I am sympathetic to these assessments, but for the purposes of this study they answer the wrong question. They explain the popular success of high energy physics, and related research in cosmology, but not why condensed matter physics failed to evoke similar responses. The stars are an object of childlike fascination, but so is magnetism – a central pillar of condensed matter physics. This fact is often flippantly associated with the hip-hop duo Insane Clown Posse. Their 2010 song “Miracles” featured the line “Fucking magnets, how do they work? / And I don’t wanna talk to a scientist / Y’all motherfuckers lying, and getting me pissed,” and became an internet meme revolving around derision of the song’s anti-science stance. The website Know Your Meme’s parsing explains that the line “implies a sense of frustration and paramount struggle in understanding basic scientific concepts, while maintaining a childlike sense of wonder over the forces of nature” (Know Your Meme 2015). That interpretation captures the essence of the

lyric, but errs in describing magnetism as belonging to the realm of elementary scientific knowledge. Although the laws of magnetic attraction have long been staples of elementary physics courses, a detailed explanation of why some materials exhibit magnetic properties did not emerge until the mid-twentieth century, and required a new quantum mechanical understanding of magnetic materials pioneered by the condensed matter physicist John Van Vleck, who is often called “the father of modern magnetism” (Keith and Quédec 1992, 413). But Van Vleck is far from a household name and the theory of magnetism he developed remains abstruse, and so the question remains why condensed matter work on magnetism has not gained greater attention on the basis of the intrinsic wonder Insane Clown Posse articulated.

John Updike’s science-themed poems offer a more high-minded example. After reading the September 1967 issue of *Scientific American*, which included a feature section on the science of materials, he penned an ode to solids. The final verse – which concludes a portrait of abstract science with the proclamation “the World we wield!” – deftly captures the tight connection many condensed matter physicists themselves saw between theoretical understanding of materials and technical mastery over them:

Magnetic Atoms, such as Iron, keep
 Unpaired Electrons in their middle shell,
 Each one a spinning Magnet that would leap
 The Bloch Walls whereat antiparallel
 Domains converge. Diffuse Material
 Becomes Magnetic when another Field
 Aligns domains like Seaweed in a swell.
 How nicely microscopic forces yield
 In Units growing Visible, the World we wield! (Updike 1969, 132)

“The Dance of the Solids” uses staid verse form and florid language archly to exalt the humble solids. It contrasts Updike’s cheeky 1960 poem “Cosmic Gall,” written in response to the discovery of the neutrino, which toys with the particle’s weakly interacting nature and finishes: “At night, they enter at Nepal/And pierce the lover and his lass/From underneath the bed – you call/It wonderful; I call it crass” (ibid., 36). Updike parodied the profundity of particle physics in comic verse, but extolled the commonplace solid state in Spenserian stanza. His ironic invocation of the comparative cultural standings of these fields highlighted the visibility and acclaim high energy physics enjoyed over condensed matter physics, but it also indicated its contingency by showing another way we might think about these phenomena – elementary particles as creepy and invasive, solids as the seat of human mastery over nature. Updike, like Insane Clown Posse (if in a somewhat different manner), seized on the potential of condensed matter to be exciting. The phenomena of condensed matter physics do not fail to fascinate, but that fascination has not been connected effectively to the science that explains the phenomena. A satisfactory explanation of prestige asymmetry in physics would have to account for why that connection fails.

A second potential reason for condensed matter physics' comparative lack of visibility is its sheer complexity. The argument from complexity proceeds in two levels, since both the professional organization of condensed matter physics and the phenomena it studies are more intricate than their analogues in high energy physics. As a professional entity, condensed matter physics unites a wide array of research programs, many of which share little common ground, giving it low internal cohesion. As a conceptual enterprise, it deals with the "many-body problem" that bedevils studies of the organizational scales at which quantum interactions become too complicated to calculate from first principles. The idealizations, approximations, and calculation tricks such physics requires to make theoretical problems tractable sometimes offend the aesthetic sensibilities of other physicists, who are wont to refer to "*Schmutzphysik*" (filth physics), or "squalid state physics" (see Joas 2011). Even Philip Anderson, when reflecting on why he had trouble recommending a good popular book on his field of study, lamented that "the simplicities of particle physics are easier to explain than the complexities of condensed matter" (United States Senate 1987, 66).

Historians too have pointed to complexity as a reason condensed matter physics has received little scholarly attention. Even compared with other highly heterogeneous scientific fields, it is "huge and varied and lacks the unifying features beloved of historians – neither a single hypothesis or set of basic equations, such as quantum mechanics and relativity theory established for their fields, nor a single spectacular and fundamental discovery, as uranium fission did for nuclear technology or the structure of DNA for molecular biology" (Hoddeson et al. 1992, viii). None of the field's most notable accomplishments, such as the theory of superconductivity or the invention of the transistor, "proved powerful enough to subjugate the diversity of condensed matter physics to a common theoretical regime, experimental program, or technical enterprise" (Martin and Janssen 2015, 633), leaving historians without an easy point of entry.

Both flavors of the complexity argument help account for why science studies scholars have paid the most populous subfield of physics little heed, and why it has struggled to gain intellectual status within physics.⁶ Complexity falls short, however, when turned to the place of physics in the public eye. The gritty details of scientific institutional organization rarely attract popular interest, and so the unusually diverse constitution of condensed matter physics should matter little for public enthusiasm for its intellectual

⁶ The lower professional status of condensed matter physics might itself be invoked to explain its unpopularity, but examples abound of visibility outside the profession developing with scant connection to intellectual standing within it. Evolutionary Psychology is a mainstay of popular media, despite challenges to its foundations from both psychology and evolutionary biology (see Dupré 2001). Ancient DNA research is similarly a popular darling despite marginal professional status (Jones 2015; 2017).

accomplishments. And communicating the conceptual content of science in the second half of the twentieth century was inevitably an exercise in simplification. High energy physics is plenty complicated itself, and aesthetic considerations that lead other physicists to adjudge condensed matter physics messy appear beyond the scale of complexity that would frustrate lay audiences. They refer to the approximations and simplification schemes that make the mathematics needed for a quantum mechanical treatment of many-body systems tractable, and not to the basic concepts underlying the science. The failure of condensed matter physics to capture the popular imagination is not evidence that it is inherently less easy to understand, only that efforts to popularize it have been less effective.

The popularity of enterprises such as string theory offers another potent counterexample to the complexity argument. This immensely complex mathematical edifice has been effectively popularized, even in the face of considerable opposition to it from other physicists, many of whom consider it recklessly speculative and fear that its total divorce from experiment renders it unscientific (Cartwright and Frigg 2007; Ritson and Camilleri 2015). Missner even cites complexity and esotericism as a boon to the popularization of relativity, calling the myth that only twelve people worldwide understood it, “probably the most important factor in the growing fame of the theory” (Missner 1985, 276). Complexity, that is, has not only failed to hinder the effective popularization of some scientific accomplishments, it has aided their dissemination. Although complexity can account in part for why condensed matter physics had drawn harsh aesthetic judgments from other physicists and received comparatively little attention from science studies scholars, it fails as an account of the field’s popular obscurity. Lack of scholarly attention might produce a second order effect diminishing public awareness; however, the regrettable distance between scholarly and public discourse suggests that this effect would be negligible.

Lack of Effort

No matter how captivating a scientific enterprise might be, it does not gain public notoriety on its own; popularization follows from the sweat of the brow. Orzel (2016) suggests that high energy physicists have had greater incentive to exert such effort. Because their research is remote from applications, they cannot avail themselves of the easy appeal to technological deliverables that condensed matter physicists enjoy. Instead, they must cultivate popular enthusiasm to ensure continued cultural and financial support. And condensed matter physicists who, by choice or necessity, leave the academy, can find a ready market for their skills in industry. High energy physicists’ skills are less in demand in the private sector, and so they are more easily drawn to popularization.

Orzel’s suggestion has some *prima facie* plausibility, but neglects the popularization efforts condensed matter physicists *have* undertaken. Several have written popular books, and these often follow

the familiar tack of tying science to a larger sense of meaning. But books by Nobel Prize winners Robert Laughlin (2005), Anderson (2011), and Leon Cooper (2014) have a much lower profile than similar works by high energy physicists, cosmologists, and string theorists. Before blaming lackluster outreach, we must consider the agency of the audience, a point made by science communication scholarship that calls into question models that cast public audiences as passive consumers of scientists' and journalists' communication efforts (see Bucchi 1998).

The commercial success of “pulp science” titles by the likes George Gamow and Fred Hoyle in the 1950s (see Gormley 2016) and, more recently, Steven Weinberg (1992), Brian Greene (1999), and Lisa Randall (2011) have encouraged others to draft on their success. In the absence of commercial traction for existing popular books by condensed matter physicists – compare the sellers ranks for the titles cited above on Amazon.com – it is little wonder that more have not taken up popular writing. Condensed matter physicists might have been less energetic popularizers of their work, but a meagre public appetite for their popular writing is also in evidence. Had existing efforts sold better, others would likely have followed.

Suggesting that condensed matter physicists lack incentives to ingratiate themselves to the public also ignores a long tradition of defending the field's intellectual merit. Condensed matter physicists worry not just that public audiences and policymakers fail to link much-ballyhooed consumer technologies with their conceptual underpinnings, but also, and sometimes more, that they fail to recognize condensed matter physics as an intellectual endeavor worthy of support for its intrinsic merits. The steady stream of industrial and government funding for technological development since the end of World War II has ensured support for research with clear deliverables, but it has not guaranteed condensed matter physicists the freedom to conduct curiosity-driven investigations. Since the late 1960s, condensed matter physicists have been combatting what Paul A. Fleury called, in a congressional hearing on the ill-starred superconducting super collider, “the myth of the single intellectual frontier” (Fleury 1991, 36). Opposition to the reductionist conviction driving Cold War high energy research – the conviction that only a unifying theory of elementary particles and forces could ever be truly fundamental – gave condensed matter physicists ample incentive to seek greater public recognition and approval (Martin 2015a).

Although fewer popular titles about condensed matter physics are available, positing this fact as an explanation for public indifference to the subject is to put the cart before the horse by neglecting the agency of public audiences. It further neglects the intermediaries who stand between scientists and the targets of their popularization efforts. Journalists, discussed in the introduction, respond to their own set of incentives when deciding what stories to push and thereby contribute to popular expectations for science communication. Editors decide which manuscripts to pursue. University and corporate publicity officers decide what stories to disseminate. Television executives and documentarians select subjects based on their

own sense of their viewership's interests. The science media available for public consumption is the product of many actors, whose goals and expectations interact in complex ways, creating many opportunities for honest efforts on the part of aspiring popularizers to be shut down or limited.

Historical Accident

Another strategy for explaining the phenomenon at hand examines the historical conditions from which various subfields of physics developed, rather than their internal attributes. Much of the popular success of high energy physics in the United States, for example, derives from the popularity of individuals like Richard Feynman. A 1965 Nobelist for his work in quantum electrodynamics – the quantum theory of how light interacts with elementary particles – Feynman won widespread renown with his tales of caddishness, bongo playing, and safe-cracking hijinks at Los Alamos during the Manhattan Project (Feynman and Leighton 1985). His fame as a curious character made him an effective scientific messenger. The condensed matter physicist best situated to replicate Feynman's popular success was John Bardeen. The co-inventor of the transistor, which powered the consumer electronics that grew ever more prevalent throughout the Cold War, and the only individual to win two Nobel Prizes in physics (the first for the transistor, the second for the Bardeen-Cooper-Schrieffer theory of superconductivity), Bardeen might have parlayed these accolades into public prominence, but he abhorred the spotlight (Hoddeson and Daitch 2002).

These superficial contingencies seem plainly inadequate to explain a phenomenon that remains stable across decades and stretches between continents. Indeed, a ready counterexample exists on the other side of the Atlantic. The two most recent British Nobel laureates in physics, Peter Higgs (for the Higgs mechanism) and Andre Geim (for graphene), contrast in ways similar to Feynman and Bardeen. Higgs is quiet and reserved, Geim outgoing and colorful, having won, in addition to his Nobel, an Ig Nobel Prize for levitating a frog inside an electromagnet (Abrahams 2010; Berry and Geim 1997). Yet a little digging shows that Geim, unlike Higgs, has not broken into pub trivia answer sheets. A firmer measure shows 2,675 results for “Peter Higgs” in LexisNexis Academic over the past six years, whereas “Andre Geim” garners 998, suggesting that the contingencies of character are inadequate to account for the effect in question.⁷

A deeper explanation might come from the political and institutional circumstances of the early Cold War, the context in which high energy and condensed matter physics began to emerge as independent (if nevertheless interdependent) physical enterprises. The rapid growth of high energy physics, in the form

⁷ Data from LexisNexis Academic, available at: <http://www.lexisnexis.com/hottopics/lnacademic/> (last accessed August 3, 2016). The range from January 1, 2010, to August 3, 2016, ensures that results include the stories announcing both physicists' Nobel Prizes, Geim's in 2010, Higgs's in 2013. A similar ratio appears in the Access World News and Infotrac Newsstand databases.

of large and expensive accelerator facilities, owes a sizeable debt to the Manhattan Project. High energy physics evolved from nuclear physics, and the intellectual acclaim and political influence nuclear physics gained based on World War II weapons research accrued to high energy physics as it split from nuclear physics during the Cold War. We might regard the primacy of high energy physics – and its cousin, astrophysics – in the public imagination as a simple extension of the prominence won by the Manhattan Project.

These deeper contingencies also prove inadequate upon examination. First, condensed matter physicists were instrumental to the war effort through their work on radar, which required novel leaps in theoretical understanding of semiconductors and exerted considerably greater influence over the course of the war than nuclear research (Brown 1999). Nuclear weapons seized public attention in a dramatic and psychologically profound instant in August 1945, whereas radar was deployed steadily throughout the war, and that contrast is relevant to the reception of each, but the psychological potency of the bomb does little to explain why radar never became associated with basic physics. Second, condensed matter physicists often shared in the political clout other physicists enjoyed. Many condensed matter physicists found themselves on the influential committees that worked behind the scenes of the Cold War security state, where expertise in fields like quantum optics was just as valuable as expertise in nuclear physics (Wilson 2015).

Furthermore, the physics of solids was integral to the Manhattan Project, as much, or even more so, than nuclear physics. By 1942, the nuclear principles at work in fission weapons were fairly well understood. What remained was a herculean engineering effort, including new investigations of the physical behavior of graphite (a moderator in reactors used to manufacture plutonium) and the metallurgical properties of uranium and plutonium. It is therefore not obvious that nuclear weapons should have become associated exclusively with nuclear physics. Rebecca Press Schwartz and David Kaiser both identify a plausible mechanism by which theoretical nuclear physics nevertheless came to be understood as the primary progenitor of nuclear weapons: the Smyth Report, the official US government account of the Manhattan Project, omitted chemical, engineering, and metallurgical knowledge that remained classified and relied instead on publically available information, most of which came from published work in theoretical physics. Schwartz demonstrates how Henry DeWolfe Smyth's affection for abstraction yielded a report that framed the Manhattan project as a triumph of theory, followed by a soupçon of tedious practical work that merited little attention (Schwartz 2008, 77). Kaiser shows how this attitude persisted through the Cold War, creating an environment in which theoretical physicists, and the sacred knowledge they commanded, were considered a unique security threat (Kaiser 2005).

Like the emotional power of cosmology, however, this offers only half an explanation for the question at hand. It is a convincing account of why the Manhattan Project was remembered as a physics

achievement, but does not explain why radar was not. Kaiser's account raises the further question of why this attitude persisted throughout the Cold War, even after historical perspective on the Manhattan Project, and the increasing remoteness of high energy physics research, might have plausibly caused it to weaken. The simple narrative in which high energy physics, as an outgrowth of nuclear physics, exclusively carried on the acclaim won by the bomb therefore proves incomplete. Nuclear physicists were not the only contributors to wartime development, or even to the bomb itself, and condensed matter physicists held comparable roles in policy circles during the Cold War. Beginning in the 1950s, Nobel citations have been approximately evenly split between condensed matter research and particle, nuclear, or astrophysics work – in part because of Alfred Nobel's wish that the award recognize accomplishments that have “conferred the greatest benefit to mankind,” which gave studies with technological relevance an advantage in Stockholm.⁸ The Cold War context does not explain why the Nobel committee routinely traced technological results back to their conceptual origins in condensed matter physics whereas a similar connection failed to materialize within the US public sphere.

Explaining Prestige Asymmetry: Technology and the Purloined Letter Effect

Technology Takes the Lede

Technological relevance is often presented as a reason condensed matter physics should be better known. But perhaps technological prolificacy itself has rendered it recondite. Organized to cater to physicists working in industry, the professional apparatus of condensed matter physics maintained close ties to technological development from its inception. Inventions such as the transistor, which appeared only a year after solid state physics was institutionalized in the form of a division of the APS, created new opportunities for a sizable bloc within the field concerned with the properties of industrially relevant materials. These practical associations might bear some responsibility for stunting the growth of condensed matter's intellectual esteem and directing public attention to practical outcomes of physical investigations rather than the investigations themselves.

Technical relevance did indeed drive some of the derogatory judgments of the field's intellectual merits from within physics. Roman Smoluchowski, the General Electric physicist who led the campaign to establish an APS solid state physics division, recalled that “solid state did have a difficult time being accepted, primary because so much of it turned out to be half engineering and that didn't sit too well with

⁸ American solid – state physicists' Nobel Prizes did not necessarily translate to intellectual prestige on home soil. Anderson complained that the 1960s and 1970s were marked by “difficulty in getting condensed matter colleagues recognized by the NAS [National Academy of Sciences], and many physics departments in major universities such as Yale, Columbia, and Princeton had only token representation in the field of condensed matter” (Anderson 2001, 1).

the purists” (Smoluchowski 1982). The APS had been founded in 1899 to serve Henry Rowland’s “pure science” ideal (Rowland 1883). Many US physicists valued their identity as “pure” scientists, insensible to potential practical implications of their work. John Van Vleck, a leading figure in US physics when solid state was forming, illustrated the barriers the pure-science ideal posed when he responded to Smoluchowski’s proposal for a new APS division by writing, “The idea that various groups whose main interest is not physics must be coddled, in order to make them members of the American Physical Society, has never appealed to me” (Van Vleck 1944). Connections to chemistry, metallurgy, and engineering were a liability for condensed matter from its inception.

The field’s technological bent remained a concern for some of its practitioners throughout the Cold War. The growing preference for “condensed matter physics” over “solid state physics” in the 1970s and 1980s was due to a desire to emphasize the field’s intellectual contributions over and above its practical applications (Martin 2015b). Federal funding patterns exacerbated these worries.⁹ Condensed matter physicists envied the relatively free rein given to their colleagues in high energy physics to explore questions of strictly intellectual interest, while their own funding was frequently aimed at practical targets. In 1970, for instance, the federal government spent \$211.7 million on high energy physics research and over \$90 million to operate basic nuclear research facilities. By comparison, \$56 million was allocated for basic condensed matter research (National Research Council 1972, 129, 327, 453). The federal funding gulf was only amplified by the comparative size of these fields, with the American Physical Society’s Division of Solid State Physics enrolling 10.8 percent of society membership, the Division of Nuclear Physics 6.9 percent, and the Division of Particles and Fields 6.3 percent.¹⁰ Condensed matter physicists competing for a smaller pot of federal research funds were more easily enticed into industrial work, which was widely regarded to be of lower intellectual status.

By the end of the 1960s, US particle physicists had resolved to focus on the frontier of higher energies, demanding larger, more expensive accelerators. “The high-energy frontier has become the financial-support frontier,” M. Stanley Livingstone, co-inventor of the cyclotron, wrote in 1968 (Livingstone

⁹ Overall funding is difficult to compare, because condensed matter physics received considerable industry support, which was not tracked as rigorously as government expenditures. However, industrial funding in the 1970s became increasingly development oriented, and so federal funding is a useful basis for comparing the support available for research that physicists at the time would have regarded as basic or fundamental (Varma 2000).

¹⁰ Note that membership in divisions dedicated to research more likely to benefit from federal expenditures on basic condensed matter physics far outpaced membership in divisions likely to benefit from expenditures on high energy and nuclear physics. In 1970, society membership in divisions dedicated to solid state physics, chemical physics, plasma physics, polymer physics, and fluid dynamics constituted 59 percent of division memberships. Membership in divisions dedicated to high energy physics, nuclear physics, and astrophysics totaled 30 percent. The remainder came from the Division of Electron and Atomic Physics.

1968, 6). The demands of larger accelerators maintained disparities between high energy and condensed matter funding through the 1970s and 1980s. In 1985, 20 percent of APS membership was enrolled in the Division of Condensed Matter Physics and 11 percent in the Division of Particles and Fields. Federal appropriations that year of \$541.9 million for high energy physics research exceeded the \$410.8 million for all of Basic Energy Sciences (BES), a federal funding category introduced in 1977 that included condensed matter physics within materials science, which itself received less than a quarter of the BES budget, and funded it alongside other physical and biological investigations of matter and energy at terrestrial scales (United States Department of Energy 1986a, 147; 1986b, 19). The BES program, in addition, was guided by near-term practical objectives, leading some condensed matter physicists to worry that it handicapped their ability to conduct curiosity-driven research. Philip Anderson described this situation in 1989 as being “caught between the Scylla of the glamorous big science projects ... and the Charybdis of the programmed research, where you have deliverables, where you are asked to do very specific pieces of research aimed at some very short-term goal” (United States Senate 1989, 134).

If technological relevance influenced condensed matter’s status within the physics community, then perhaps it can also help account for its public obscurity. Evidence from science journalism suggests a mechanism by which technological associations could have this effect. From the perspective of science reporters, a device is easier to fit into a narrative than the sometimes-arcane science behind it. Kenneth Chang, in the 2006 edition of *A Field Guide for Science Writers* points out that reporting on high-temperature superconductivity, one of the few topics in condensed matter physics that is routinely deemed newsworthy, invariably invokes the possibility of levitating trains, before cautioning: “That sounds cool. But it provides little context about what scientists and engineers find intriguing about these materials, what their advantages and disadvantages are, what the hurdles are for making useful devices out of them. Plus, high-temperature superconductors were discovered in 1986. Have you seen an Amtrak levitate recently?” (Chang 2006, 2010). Technology, actual or potential, can upstage science, causing specialties with strong applied components to face greater difficulty gaining widespread recognition for their intellectual output. And when, such as in the case of high-temperature superconductivity, the promised technology fails to materialize, disappointment and disillusion invariably follow.

Examining how major US newspapers have reported physics shows this effect in action. Through the second half of the twentieth century, the annual Nobel Prize announcement was one of the few times physics was widely reported, and even had a reasonable shot at front-page column inches. The ways in which newspapers reported Nobel announcements demonstrate both the gulf between reporting on high energy physics on one hand and condensed matter physics on the other, and the manner in which

technologies, often mundane and only tangentially related the intellectual accomplishments being discussed, took up all the air in the room when condensed matter was the topic of discussion.

Table 1. Physics Nobel Laureates in the 1970s

Year	Winner and Nationality	Subfield	Citation
1970	Hannes Olof Gösta Alfvén (Sweden)	Plasma	“for fundamental work and discoveries in magnetohydrodynamics with fruitful applications in different parts of plasma physics”
	Louis Néel (France)	Condensed matter	“for fundamental work and discoveries concerning antiferromagnetism and ferrimagnetism which have led to important applications in solid state physics”
1971	Dennis Gabor (Hungary/UK)	Optics	“for his invention and development of the holographic method”
1972	John Bardeen (US)	Condensed matter	“for their jointly developed theory of superconductivity, usually called the BCS-theory”
	Leon Neil Cooper (US)	Condensed matter	
	John Robert Schieffer (US)	Condensed matter	
1973	Leo Esaki (Japan)	Condensed matter	“for their experimental discoveries regarding tunneling phenomena in semiconductors and superconductors, respectively”
	Ivar Giaever (US/Norway)	Condensed matter	“for his theoretical predictions of the properties of a supercurrent through a tunnel barrier, in particular those phenomena which are generally known as the Josephson effects”
	Brian David Josephson (UK)	Condensed matter	
1974	Martin Ryle (UK)	Astro	“for their pioneering research in radio astrophysics: Ryle for his observations and inventions, in particular of the aperture synthesis technique, and Hewish for his decisive role in the discovery of pulsars”
	Antony Hewish (UK)	Astro	
1975	Aage Bohr (Denmark)	Nuclear	“for the discovery of the connection between collective motion and particle motion in atomic nuclei and the development of the theory of the structure of the atomic nucleus based on this connection”
	Ben Roy Mottelson (Denmark)	Nuclear	
	Leo James Rainwater (US)	Nuclear	
1976	Burton Richter (US)	High Energy	“for their pioneering work in the discovery of a heavy elementary particle of a new kind”
	Samuel Chao Chung Ting (US)	High Energy	
1977	Philip Warren Anderson (US)	Condensed matter	“for their fundamental theoretical investigations of the electronic structure of magnetic and disordered systems”
	Nevill Francis Mott (UK)	Condensed matter	
	John Hasbrouck Van Vleck (US)	Condensed matter	
1978 ¹¹	Pyotr Lenidovich Kapitsa (USSR)	Condensed matter	“for his basic inventions and discoveries in the area of low-temperature physics”
	Arno Allan Penzias (US)	Astro	“for their discovery of cosmic microwave background radiation”
	Robert Woodrow Wilson (US)	Astro	
1979	Sheldon Lee Glashow (US)	High Energy	“for their contributions to the theory of the unified weak and electromagnetic interaction between elementary particles, including, inter alia, the prediction of the weak neutral current”
	Abdus Salam (Pakistan)	High Energy	
	Steven Weinberg (US)	High Energy	

Data from Nobelprize.org

¹¹ The 1978 prize, shared between the United States and the Soviet Union, and between condensed matter and astrophysics, would have made an apt case study, but the *New York Times* was silenced by a strike from August to November and the wire services offered only cursory coverage.

The analysis presented here focuses on coverage of Nobel Prize announcements in a few prominent publications in the 1970s, which exposes trends indicative of coverage in late-twentieth century US news outlets. By that time, the *New York Times* was nationally distributed and broadly regarded as the newspaper of public record. The *Chicago Tribune* and the *Los Angeles Times* were the principle papers in the two other largest population centers in the United States, with the former commonly carrying Reuters and the latter Associated Press (AP) wire reports, making them indicative of the coverage available to a significant proportion of the American populace. The 1970s exhibit a number of features besides that make the decade a useful exemplar of public exposure to physics after World War II. First, Nobel Prizes were evenly split between condensed matter physics and high energy, nuclear, and astrophysics. Second, researchers in the United States won a significant number of physics prizes in the 1970s – thirteen of twenty-five physics laureates in the 1970s worked at US institutions – ensuring prominent coverage. Third, the 1970s saw tensions mount between condensed matter physicists and high energy physicists over intellectual prestige and research funding (see Anderson 2001; Martin 2015a). Finally, despite competition from television, newspapers remained prominent. The 1970s saw a local high-water mark in the number of daily papers in the United States before a decline in the 1980s, and it was marked by steady daily and increasing Sunday distribution (Newspaper Association of America 2016).

Reporting on prizes for high energy physics in this era, and prizes in the closely related fields of astrophysics, nuclear physics, and cosmology, emphasized intellectual achievement and often went to great lengths to explain the scientific concepts involved. It avoided drawing connections to technical consequences of the work in question, even when such connections might have been evident. In 1974, after discussing the chemistry prize awarded to Paul J. Flory for his work on synthetic polymers, a field with manifest industrial applications, Boyce Rensberger of the *New York Times* wrote: “At almost the other extreme in the spectrum of scientific subjects from molecules is the exploration of the universe that has been carried out by Dr. [Martin] Ryle and Dr. [Antony] Hewish” (Rensberger 1974, 26). Despite relating the technical improvements to radio antenna behind the astronomical work leading to the discovery of pulsars, the article did not explore practical implications of those developments, focusing on explorations of the distant universe instead. Nor did the *LA Times* or the *Tribune* draw such connections; the latter made only the quixotic suggestion that “technique opens up the possibility of contact with possible intelligent creatures in outer space” (*Los Angeles Times* 1974; *Chicago Tribune* 1974, 13).

The following year, Aage Bohr, Ben Mottelson, and James Rainwater won for clarifying the structure of the atomic nucleus. The title of the *NY Times* story, “Three Physicists Unravel Mystery: Nobel Winners Showed and Explained the Asymmetry of Atomic Nucleus,” triumphantly introduced a painstaking attempt to explain the nuclear shell model in simple terms (Sullivan 1975, 15). In 1976,

celebrating Burton Richter's and Samuel Ting's simultaneous discovery of the J/Ψ meson, the *NY Times* cast them in a centuries-long drama: "For centuries, physicists and chemists have devoted much of their efforts to a search for the smallest components of matter. The limit of the smallest has slowly been moved from atoms via atomic nuclei to what are known as elementary particles. For some years now, physicists have had to move the limit downward, and indications are that elementary particles, too, consist of yet smaller units called quarks" (Semple Jr. 1976, 34). The *Tribune* quoted Richter: "The significance is that we have learned something more about the structure of the universe. In terms of practical application right now, it's got none" (*Chicago Tribune* 1976, 2). Steven Weinberg, Sheldon Glashow, and Abdus Salam's prize for electroweak unification rounded out the decade. Both the *LA Times* (1979) and the *Tribune* (1979) carried wire reports that gave prominent billing to Weinberg's and Glashow's statements about the fundamental importance of their work for understanding the way the universe works – and its manifest absence of practical applications. The *Gray Lady* toasted "a theory so profound as to affect man's perception of existence" (Browne 1979, 1).

The 1970s condensed matter prizes all recognized fundamental contributions, in particular theoretical developments in magnetism and work on the quantum properties of solids. US papers nevertheless routinely described these contributions as undergirding technological developments, with efforts to explain the content of the research either perfunctory or absent. In 1970, reporting Louis Néel's prize for fundamental contributions to the study of magnetism, the *NY Times* described "research in basic magnetism that has had an impact on computers, telephones and microphones" (Weinraub 1970, 26). The wire services touted "wide applications" (*Los Angeles Times* 1970) to "telegraphy, telephony, radio and television, ... engines, loudspeakers and microphones" (*Chicago Tribune* 1970). Two years later, the *NY Times* report on the prize for the Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity, one of the most intractable theoretical problems in physics since the phenomenon was first observed in 1911, quoted Erik Rudberg, Secretary of the Swedish Royal Academy of Sciences, as saying, "We can say that the application of superconductivity is important not only for scientific instruments, but also for accelerators and motors" (Weinraub 1972, 14). The *LA Times* ran an AP report with the headline "Nobel Team's Theory Finds Practical Uses" (*Los Angeles Times* 1972a, 8), which quoted Schrieffer discussing efforts to apply superconductivity that had been underway well before BCS was published.

Not only did journalists pivot to technical stories when covering condensed matter physics, they often emphasized the most pedestrian of technical applications. In 1973, *NY Times* readers learned that Leo Esaki, Ivar Giaever, and Brian Josephson, who had advanced understanding of quantum tunneling phenomenon in solids, the former two with exotic experimental setups, "made discoveries regarding phenomena unfamiliar to the layman, yet vital to his television set or the computers that affect many

aspects of his life” (Sullivan 1973, 26). The 1977 prize recognized theorists Philip Anderson, John Van Vleck, and Nevill Mott. The Nobel committee cited them “for their fundamental theoretical investigations of the electronic structure of magnetic and disordered systems.” The *NY Times* reported that the winners “were cited for work underlying the development of computer memories, office copying machines and many other devices of modern electronics,” and made little effort to clarify the theoretical work behind the prize (*New York Times* 1977, 1). The AP report pointed to lasers, better glass, and copper IUDs (*Los Angeles Times* 1977, A2). Reuters tied the laureates’ “‘solid state’ physics theories” to “computer memories, pocket calculators, modern radios, office copiers, and solar energy converters” (*Chicago Tribune* 1977, 2). The emphasis was not only squarely on technology, but disproportionately on the work-a-day technologies that were becoming part of the furniture of Cold War America. High energy physics changed our perceptions of our very existence; condensed matter was the physics of photocopiers.

High energy physics had success communicating its intellectual mission through news coverage in part because of where it sat relative to other physics fields and scientific disciplines. Anderson once griped that high energy physicists had cultivated “a narrow, inbred field,” so that they therefore found it easy “to create an external appearance of unanimity of goals” (United States House 1991, 67). Anderson disdained such isolation, but relative distance from both applications and from other sciences meant that high energy physicists could easily claim sole parentage of their intellectual accomplishments and present those accomplishments as the singular purpose of their labors. The many crossties, overlaps, and intersections between condensed matter physics and other scientific and technological enterprises, on the other hand, made its intellectual achievements harder to defend from neighboring fields that might claim them. Walter Kohn, once a proud physicist, would win his Nobel Prize in chemistry because chemists were the first to find widespread use for the density functional theory he had helped develop (Zangwill 2015). Prizes for physics sometimes went to engineers such as Jack Kilby. A field that shared so liberally with neighboring fields had a harder time laying firm claim to its intellectual possessions, making the temptation to see it in technological terms all the stronger.

In sum, US media coverage of the Nobel Prize played into the aspirational values of science when reporting on certain types of physics, but retreated to the mundane world of consumer products and industrial applications when faced with others. Even when relating what many physicists regarded as some of the most profound intellectual accomplishments of the century, newspapers consistently gave top billing to familiar, commonplace devices. Reports of prizes in more rarefied fields often adopted the soaring rhetoric and distain for applications favored by physicists in those fields themselves. The cumulative effect was that public presentations of condensed matter physics directed attention toward technology and away from science, whereas analogous presentations of high energy physics accomplishments followed the

rhetoric of the physicists themselves by placing emphasis squarely on intellectual merit, championing science as a triumph of the human mind, and explicitly disavowing practical tie-ins. This contrast does not indicate in any unproblematic way how these portrayals were received, but it does document a widespread difference in the vocabulary used to discuss these fields in the public sphere, which in turn – while remaining agnostic about any causal connection or direction – is likely to reflect a difference in the way they were perceived more broadly.

The Purloined Letter Effect

A further explanation derives from considering what values the discourse surrounding different branches of physics affirm. Studies of science education have argued that conveying scientific information perforce communicates a set of values along with it (Burkhardt 1999), an insight that can be extended to the didactic news coverage that accompanies Nobel announcements. Building on research that shows how science provides a source of faith in human potential for a significant and growing portion of the public (Evans 2014; Midgley 1992), we can ask to what extent public presentations of various subfields of science are compatible with an aspirational vision of science. The values communicated in the discourse of discovery that surrounds condensed matter physics often cut conspicuously against that vision. Undermining the image of science as a testament to human potential can hinder attempts to engage the public and contribute to popular obscurity.

Edgar Allan Poe's 1844 short story "The Purloined Letter" depicts the eminently astute C. Auguste Dupin putting the Parisian police to shame by recovering a stolen letter that their detailed searches had failed to uncover. The prefect of the police, in soliciting Dupin's assistance, recounts a search so thorough that, as Dupin explains, "had the purloined letter been hidden anywhere within the limits of the Prefect's examination – in other words, had the principle of its concealment been comprehended within the principles of the Prefect – its discovery would have been a matter altogether beyond question" (Poe 1852, 273). He concludes from the prefect's failure, and from his own assessment of the thief as a clever man familiar with the methods of the police, that the letter must be hidden in plain sight, disguised as a document of little interest. Dupin solves the mystery of the purloined letter, but in a way that exposes the Procrustean habits of the police. We admire his cleverness only in contrast to our disdain for the prefect, whose limitations prevented him from seeing that which was hidden in plain sight.

The purloined letter effect, therefore, describes the consequences of intellectual accomplishments that we can appreciate only alongside the sheepish acknowledgment that the answer was in some way in

front of our noses all along.¹² Such accomplishments might be ingenious, but, in contrast to discoveries that are presented as pushing into a frontier where anything waiting to be discovered is new, they also draw attention to the failure of others to discover something that was obvious to anyone who observed the problem in the right way. High energy physics is rife with frontier rhetoric (see Hoddeson and Kolb 2000), through which it casts itself as a paragon of human potential. Condensed matter physics deals with phenomena at human scales and is associated with familiar technologies, so its discoveries are more susceptible to the purloined letter effect, which can be discerned by examining the rhetoric of discovery surrounding condensed matter physics.

In the 2000s, the physicist Andre Geim, then at Radboud University Nijmegen in the Netherlands, enjoyed a modest celebrity for demonstrating diamagnetic levitation of a living frog in the bore of an electromagnet (Berry and Geim 1997). In 2000, that flying frog netted him an Ig Nobel Prize – a tongue-in-cheek award bestowed upon amusing, absurd, or otherwise “improbable” research – which Geim proudly traveled to Cambridge, Massachusetts, to accept.¹³ Ten years later, by which time he had moved to the University of Manchester, he journeyed east instead of west to receive the 2010 Nobel Prize in Physics, making him the only individual to win both. The work that led to both awards, Geim notes, grew out of the same research style, which involved setting aside time to try out simple, but interesting ideas outside his main research agenda. In many cases, this led Geim’s research group to examine phenomena that were overlooked and underappreciated, or that flouted entrenched disciplinary traditions (Geim 2010).

The Nobel Prize that Geim won with his colleague and former PhD student Konstantin Novoselov recognized their work probing the distinctive properties of graphene, which they peeled from blocks of graphite using ordinary cellulose sticky tape – work very much in that spirit. Consisting of a sheet of carbon atoms one atomic layer thick, graphene is a material with surprising properties (Castro Neto et al. 2009), implications for our basic understanding of quantum phenomena (Zhang et al. 2005), and a wide range of potential practical uses (Geim 2009). Geim is fond of noting with more than a hint of impish glee that graphene has been under our noses for centuries – small flakes are present, for example, in the markings of a graphite pencil. In his Nobel lecture, Geim underplayed graphene’s novelty by insisting that the material for which he was honored was far from exotic:

The layered structure of graphite was known since early days of X-ray crystallography, and researchers certainly have been aware of graphite being a deck of weakly bonded graphene planes for an even longer time. This property has been widely used to create a variety of intercalated

¹² I therefore use the term differently than did Clifford Geertz, who wrote: “There is something ... of the purloined letter effect in common sense; it lies so artlessly before our eyes it is almost impossible to see” (Geertz 1983, 92).

¹³ For more on the Ig Nobel Prizes, see <http://www.improbable.com/ig/>.

graphite compounds and, of course, to make drawings. After all, we now know that isolated monolayers can be found in every pencil trace, if one searches carefully enough in an optical microscope. Graphene has literally been before our eyes and under our noses for many centuries but was never recognized for what it really is. (Geim 2010)

Geim suggests that his only novel contribution was to take something that had been observed many times before and ask what its properties were. He was doing physics at the pencil-point frontier, pushing forward knowledge of our quotidian surroundings. A 2014 story about graphene in *The New Yorker* reinforced this point, quoting the synthetic organic chemist and graphene researcher James Tour: “all these years scientists are trying to figure out some great thing, and you’re just stripping off sheets of graphene as you use your pencil. It has been before our eyes all this time!” (quoted in Colapinto 2014).

In contrast to the extremophilia that marks high energy physics, condensed matter physics confronts phenomena at terrestrial scales, where Geim would say that there is a great deal we still do not know, as graphene demonstrates. Geim’s account of graphene gives the lie to some of the most meaning-laden physical enterprises, such as the search for a “theory of everything” that has motivated much of recent high energy physics research and attracted considerable popular attention, but which condensed matter physicists find overblown (Laughlin and Pines 2000). How can we claim to have a theory of everything if we do not even understand the pencil scratchings we use to write it down? C. Auguste Dupin would take no small delight in graphene.

Pointing out that a discovery has been before us all along is *both* a celebration of insight *and* an indictment of human ingenuity. It counterbalances veneration of discovery with recognition of the Procrustean patterns into which science often falls. Such rhetoric is a common feature of discussions of condensed matter discoveries. When the Swedish Academy of Sciences announced the 2014 Nobel Prize in Physics, for the invention of the blue light emitting diode, they asserted that Isamu Akasaki, Hiroshi Amano, and Shuji Nakamura “succeeded where everyone else had failed” (Royal Swedish Academy of Sciences 2014). Bell Telephone’s own publicity magazine noted of the transistor: “This discovery is a good instance of a phenomenon existing for years unobserved right under our noses. One wonders what equally important effects are awaiting discovery by someone with sufficient curiosity to look for them” (*Bell Telephone Magazine* 1949, 240).

Such judgments can be found about the physics of materials even well before the heyday of condensed matter physics. The British physicist Arthur Schuster reported a conversation with Gustav Kirchhoff about the discovery of photoconductivity: “When I told him of the discovery then made in England, that light falling on the surface of a bar of selenium altered its electrical conductivity, he remarked ‘I am surprised that so curious a phenomenon should have remained undiscovered until now’” (Schuster

1911, 9). Schuster's comment reflects the late-nineteenth-century attitude that physics was nearing its end. This attitude was significantly undermined by the advent of relativity and quantum theory in the early twentieth century, but the sense that our understanding of terrestrial-scale phenomena was more or less complete persisted, as did the surprise that routinely accompanied the discovery of new material structures, behaviors, and properties.

The mere fact that the discourse around a discovery describes it as hiding in plain sight, however, does not ensure that it will receive less attention. Some powerful examples show quite the contrary. John Norton, discussing the myths surrounding Einstein's discovery process, identifies the mistaken notion that Einstein was a childlike naïf, asking obvious questions that the experts had overlooked, as a powerful component of the widespread perception of his genius (Norton 2016). What distinguishes the insights that appear so naïve they are brilliant from those that seem so apparent that we feel foolish for having missed them, and why should condensed matter discoveries belong to the latter category?

Drawing this distinction requires understanding the contexts into which scientific discoveries are born. Einstein's theory of relativity followed a period of hand-wringing within the physics community about the impending end of the field. It seemed that Newtonian mechanics, as reformulated by Joseph-Louis Lagrange in the eighteenth century, was a completed theory. When combined with Maxwell's electrodynamics, as formalized by Oliver Heaviside, it promised a total account of the physical world; all that remained was some buffing around the edges.

Nineteenth-century physics was weary, doddering, and almost finished. If Einstein's theory made it seem obtuse, then all the better. But the beginning of the Cold War saw the rise of science as a source of secular meaning about the world for a large segment of Western society. It was a critical weapon in the struggle between the United States and the Soviet Union for military superiority and national prestige. When science is the key to the continued existence of a way of life, or a primary source of meaning about the world, then it is profoundly worrying to have its fundamental limitations pointed out. We might regard discoveries like graphene or the transistor as clever, perhaps even indicative of a childlike willingness to ask naïve-but-deep questions, but if we also derive values and a sense of meaning from the enterprise whose flaws the discovery forces us to see, then that admiration will be tinged with bitterness.

Condensed matter physicists have occupied that position since the end of World War II. They garnered credit for technological accomplishments (even when they did not ask for it), but as consumer technology that was based, however remotely, on condensed matter discoveries became more ubiquitous, those discoveries began to appear correspondingly less impressive. The relentless focus on technology in the press turned attention away from the intellectual dimensions of condensed matter research. And when the intellectual dimension was emphasized, it had the effect of suggesting that science's claims to being a source

of secular meaning might be misguided or overblown, an effect only heightened by the mundane nature of the technologies commonly associated with condensed matter physics.

Conclusion

In closing, I would like to revisit – and revive – the four explanations I critiqued above. Taking the two phenomena above – tendency of technology to take the lede and the purloined letter effect – in conjunction offers an interpretive context in which previous explanations, which would otherwise fall short, gain new significance. Within that context, both the emotional power of cosmology and the complexity of condensed matter physics can help us interpret the dynamics of the newspaper reporting that presented these fields to the American public. And the purloined letter effect gives us both a more satisfying explanation in terms of the features of the historical context, and a reason that condensed matter physicists' popularization efforts were less potent, not simply less prevalent.

The technological focus of reporting on condensed matter Nobel Prizes often created a mistaken sense that the prizes had been awarded for technological outcomes. And although technology can be psychologically powerful, the effect wears off as technological marvels become familiar. Nothing, perhaps, illustrates this better than the *Los Angeles Times* announcement of John Bardeen's second Nobel Prize, for BCS. A brief story accompanying the main announcement described how his celebration at the University of Illinois was delayed because his automatic garage door opener, running on the transistors for which he had won his first Nobel, malfunctioned and trapped his car in the garage, requiring the university to dispatch a ride to whisk him away while his wife tinkered with the recalcitrant device (*Los Angeles Times* 1972b, 8). Fascination with the machinery of nature is timeless, but machinery itself holds us in its thrall only until it breaks.

Although the emotional power of cosmology and condensed matter's complexity tell us little on their own about why condensed matter physics has remained obscure, the rhetoric of newspaper reports allows us to see them anew. All modern physics is complex to lay audiences, so reporting on all fields demands that journalists reach for a hook to render the subject broadly palatable. In the case of high energy physics, the hook was the emotional power of cosmology, articulated in terms of basic curiosity about the architecture of the universe and humanity's place in it. That hook dovetailed with the case for the intellectual significance of high energy physics, which lent additional significance the tendency of high energy and astrophysicists to insist upon their work's lack of technological relevance. The option to invoke technology in condensed matter stories – however shaky the actual relationship between fundamental research and commercial or industrial applications – meant that science reporters were not forced to confront the complexity of the science as they were when covering fields that disavowed technological

relevance. And focusing on basic intellectual fascination in addition to technology would be to commit the journalistic sin of telling two stories in one. Applications and basic intellectual curiosity were two different narratives, and the former routinely won out in coverage of condensed matter physics.

Poe began “The Purloined Letter” with a Latin epigraph, which translates, “Nothing is more abhorrent to wisdom than excessive cleverness.”¹⁴ Some forms of wit sometimes do not merely fail to project wisdom; they do violence to it. The purloined letter effect operates much in this way. Sciences of the superlatively distant and extreme garner superlative praise; traveling to previously obscure places and drilling down to never-before-accessed scales stand as testaments to human ingenuity. But scientific work that relies on new or idiosyncratic approaches to the stuff that surrounds us – or that *created* the stuff that surrounds us – runs the risk of undermining science as a secular source of meaning by highlighting the ways in which it routinely fails to uncover apparently obvious features of the proximate world. The physics of the matter that surrounds us amounts to a purloined letter; cleverly hidden, to be sure, but whose discovery throws the perspicacity of our scientific insight into doubt, and reminds us of all that we do not know, rather than all that we are capable of discovering.

The purloined letter effect can revive the case for historical accident and, to a lesser extent, lack of popularization efforts by condensed matter physicists. The growth of science as a secular ideology, shaping which values were most compatible with popular expectations for science, can certainly be understood as a historical contingency. We need to dig further into the history, not just of the science itself, but of the society that supports it, to understand how the rise of science as a source of secular meaning influences the prestige asymmetry between its subfields. The purloined letter effect also helps us better see why condensed matter physicists’ efforts to promote their intellectual accomplishments were less commercially successful, and so less imitated: the work they promoted failed to speak to, and in many cases actively undercut, the dominant popular ideology of science.

I close by returning to the question of how the concepts developed here might apply beyond physics in the Cold War-era United States. The phenomenon of prestige asymmetry is by no means confined by topical, temporal, or geographical parameters. From the importance of astronomy to Ancient Greek and Mesopotamian culture (Rochberg 2004), to botany’s prominence in eighteenth- and nineteenth-century Britain (Endersby 2008), to the French affection for nuclear power (Hecht 2009), examples abound of some epistemic and technical practices gaining prominence over others in ways that reveal noteworthy features of the societies that embrace them.

¹⁴ Poe attributed the quote, “*Nil sapientiae odiosius acumine nimio*,” to Seneca, but it appears most approximately in Petrarch, where it is “*Nihil sapientiae odiosius acumine nimio*” (Petrarchæ 1605, 56).

The extent to which the mechanisms of technical adjacency and the purloined letter effect account for prestige asymmetries in other fields, other eras, and other national contexts is a question for additional research. The example of US condensed matter physics nonetheless provides some preliminary indications of how these concepts might be extended and how they might have to be rethought in other contexts. The particular way in which technology outshone science in popular depictions of condensed matter physics was idiosyncratic, and depended on the growth of American technological consumerism. And indeed, in other times and places, such as nineteenth century Britain, close connections between physics and technology worked in favor of the former (Morus 2005). This contrast suggests both the contingency and the malleability technology's influence over scientific prestige and raises questions about the media's role in shaping the relationship between physics and technology in Cold War America that have yet to be explored.

The purloined letter effect would seem to hold greater possibilities to help clarify other cases of prestige asymmetry. The literature on developmental and organismal biology suggests that these fields might offer a particularly enlightening basis for testing the further applicability of the purloined letter effect. Erika Milam's account of the US organismal biology community and its efforts to define itself against the hegemony of molecular biology contains strong parallels to the story of condensed matter physics and its struggle against the high energy hegemony (Milam 2010). Molecular evolution combined the reductionism of physio-chemical methods with the allure of origins, and championed the power of the human mind to illuminate the murk of deep time. Organismal and developmental biology confronted phenomena more easily observed with the naked eye, and so quite likely faced the same sorts of challenges as condensed matter physics.

This example also focuses squarely on the twentieth-century Anglophone world, in which, I would suggest, both the rhetoric of scientific discovery and the values of the surrounding culture created conditions conducive to the purloined letter effect. The peculiarities of Cold War America indeed feature strongly in the story above. The mythos of the frontier is a distinctive feature of American cultural mythology, widespread public commitment to science as a source of meaning is a relatively recent phenomenon, and the Cold War era was a period of unprecedented growth, social currency, and relevance to national aims for US physics. But that is not to say that the purloined letter effect, or similar effects as yet unnamed, might not manifest against a different cultural backdrop. I hope this paper has presented an approach to comparing the values endemic to a cultural setting with those promoted in the rhetoric of scientific discovery, which can reveal the patterns that help create and reinforce prestige asymmetries.

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